two, an afferent and a motor, just as, in Man, the double function of an ordinary spinal nerve is divided in the head between the 5th and 7th pairs. And it seems not unlikely that while the "axial cords" (motor nerves) of the arms are derived from the peripheral part of the Crinoidal axis, the "ventral bands" (sensory nerves) are derived from the central part of that axis, which has been shown to be continued, as the "axial prolongation," to the oral ring.

The Society then adjourned over the Easter Recess, to Thursday, April 27, 1876.

April 27, 1876.

Dr. J. DALTON HOOKER, C.B., President, in the Chair.

The Presents received were laid on the table, and thanks ordered for them.

The Bakerian Lecture, "On the Gaseous State of Matter," was delivered by Prof. T. Andrews, LL.D., F.R.S., Vice-President of Queen's College, Belfast. The following is an Abstract:—

After referring to certain modifications in his former method of working at high pressures, the author describes some preliminary experiments which were undertaken to determine the change of capacity in the capillary bore of the glass tubes under the pressures employed. From these experiments it appears that, on raising the pressure from 5 to 110 atmospheres, the capacity was increased for each atmosphere by only 0·0000036, and that this change of capacity was chiefly due to compression of the internal walls of the glass tube. Another set of experiments was made to ascertain whether air or carbonic-acid gas is absorbed at high pressures to any appreciable extent by mercury. For the method of operating and other details reference must be made to the original memoir; but the general result is that no absorption whatever takes place, even at pressures of 50 or 100 atmospheres. The pressures are given according to the indications of the air-manometer in the absence of sufficient data (which the author hopes will be soon supplied) for reducing them to true pressures. In the mean time it is probable, from the experiments of Cailletet, that the indications of the air-manometer are almost exact at 200 atmospheres, and for lower pressures do not in any case deviate more than $\frac{1}{80}$ from the true amount.

In a note which was published last year in the 'Proceedings' of the Society (No. 163), it was stated that the coefficient of expansion (α) for heat *under constant pressure* changes in value both with the pressure and

with the temperature. The experiments on this subject are now completed, and are described at length in this paper. The final results will be found in the two following Tables. In the first Table the values of α are referred to a unit volume at 0° and under one atmosphere. In the first column the pressure p in atmospheres is in terms of the air-manometer.

p.	α (0°–7°·5).	α (0°–64°).	α (64°–100°).
17·09	.....	0·005136	0·004747
20·10	0·00607	0·005533	0·004958
22·26	.....	0·005811	0·005223
24·81	0·00700	0·006204	0·005435
27·69	0·00782	0·006737	0·005730
31·06	0·00895	0·007429	0·006169
34·49	0·01097	0·008450	0·006574

For higher pressures than 35 atmospheres a different unit volume must be taken, on account of the liquefaction of the carbonic acid. The next Table contains the values of α, *referred to the unit volume at* 64°, between 64° and 100° at constant pressures up to 223 atmospheres.

p.	α (64°–100°).	p.	α (64°–100°).
17·09	0·003572	46·54	0·004946
20·10	0·003657	54·33	0·005535
22·26	0·003808	64·96	0·006512
24·81	0·003892	81·11	0·008033
27·69	0·004008	106·90	0·013150
31·06	0·004187	145·50	0·018222
34·49	0·004266	223·00	0·008402
40·54	0·004596		

As the value of α changes with the temperatures, the coefficients given above are average coefficients for the ranges of temperature specified. It will be observed that the value of α increases with the pressure until a very high pressure is attained, when it changes its direction and diminishes. This apparent anomaly depends upon the carbonic acid at the high pressure having passed from the gaseous state proper to the intermediate conditions, which the author has formerly described as establishing a continuity between the gaseous and liquid states of matter.

If we designate by α' the coefficient of elastic force when a gas is heated under a constant volume, we shall have in the case of a perfect (ideal) gas

$$\alpha = \alpha'.$$

In the ordinary gaseous state the value of α' diverges widely at high pressures from that of α, as will appear from the two following Tables. In the first Table the values of α' are referred to a unit pressure at 0°, and p is the initial pressure in atmospheres.

p.	α' (0°–6°·5).	α' (0°–64°).	α' (64°–100°).
16·42	.....	0·004754	0·004607
21·48	0·00537	0·005237	0·004966
25·87	0·00588	0·005728	0·005406
30·37	.....	0·006357	0·005861
33·53	0·00734	0·006973	0·006334

In the next Table the value of α' between 64° and 100° referred to a unit pressure at 64° is given for a large range of pressure. Both the initial and final pressures are given.

p.	α' (64°–100°).	p.	α (64°–100°).
21·42 24·19	0·003526	48·40 56·16	0·004387
28·65 32·60	0·003718	67·65 80·99	0·005392
35·29 40·44	0·003956	94·27 118·60	0·007018
42·74 49·25	0·004166		

As the general result of this investigation, it follows that in the ordinary gaseous state the law of Gay-Lussac does not hold good, either in the case of α or of α', and that the dilatation *by heat of a body in the ordinary gaseous state, whether measured by its expansion under constant pressure or by the increase of elastic force under constant volume, is not a simple function of the initial volume or initial elastic force, but a complex function changing with the temperature.*

In the second part of the paper the general properties of the ordinary gaseous state are considered. As the basis of this inquiry, the following Table of the compressibility of carbonic acid at 6°·5, 64°, and 100° is given, in which ϵ is the ratio of the observed volume of the carbonic acid at the pressure p and temperature t' to its volume under one atmosphere at the same temperature t'.

p.	$t'=6°{\cdot}5$, ϵ.	p.	$t'=64°$, ϵ.	p.	$t'=100°$, ϵ.
12·01	$\frac{1}{12{\cdot}95}$	17·60	$\frac{1}{18{\cdot}57}$	20·17	$\frac{1}{20{\cdot}98}$
13·22	$\frac{1}{14{\cdot}37}$	20·36	$\frac{1}{21{\cdot}65}$	22·37	$\frac{1}{23{\cdot}35}$
14·68	$\frac{1}{16{\cdot}13}$	22·56	$\frac{1}{24{\cdot}18}$	24·85	$\frac{1}{26{\cdot}09}$
17·09	$\frac{1}{19{\cdot}12}$	25·06	$\frac{1}{27{\cdot}08}$	27·76	$\frac{1}{29{\cdot}32}$
20·10	$\frac{1}{23{\cdot}03}$	28·07	$\frac{1}{30{\cdot}64}$	31·06	$\frac{1}{33{\cdot}05}$
22·26	$\frac{1}{25{\cdot}96}$	31·39	$\frac{1}{34{\cdot}67}$	34·57	$\frac{1}{37{\cdot}09}$
24·81	$\frac{1}{29{\cdot}62}$	34·92	$\frac{1}{39{\cdot}08}$	40·09	$\frac{1}{43{\cdot}54}$
27·69	$\frac{1}{34{\cdot}03}$	40·54	$\frac{1}{46{\cdot}34}$	45·99	$\frac{1}{50{\cdot}63}$
31·06	$\frac{1}{39{\cdot}59}$	46·56	$\frac{1}{54{\cdot}57}$	53·81	$\frac{1}{60{\cdot}30}$
34·49	$\frac{1}{45{\cdot}80}$	54·33	$\frac{1}{65{\cdot}97}$	64·27	$\frac{1}{73{\cdot}97}$
		64·96	$\frac{1}{83{\cdot}44}$	80·25	$\frac{1}{96{\cdot}65}$
		81·11	$\frac{1}{114{\cdot}0}$	105·69	$\frac{1}{137{\cdot}6}$
		106·88	$\frac{1}{185{\cdot}5}$	145·44	$\frac{1}{218{\cdot}0}$
		145·54	$\frac{1}{325{\cdot}9}$	223·57	$\frac{1}{379{\cdot}3}$
		222·92	$\frac{1}{446{\cdot}4}$		

If we put $\rho=\epsilon p$, and calculate the values of ρ for each of the above experiments, it will be found that these values diminish regularly as the pressure increases at each temperature, with the exception of the last observation at 64°, where the value of ρ is greater than at the preceding observation. This change of direction in the value of ρ is explained by the circumstance already mentioned, that the carbonic acid at the higher pressure has been reduced to the liquid volume (although no liquefaction has taken place) in passing through the conditions of matter intermediate between the gaseous and liquid states.

The relations between the volumetric curves in the ordinary gaseous state for different temperatures are determined by means of what the author calls the homologues or homologous points of those curves—that is, the points in any two isothermals where the values of ρ are equal, or

$$p\,v=p'\,v'. \quad \text{(A)}$$

From a careful analysis of the experiments described in this communication and in his former Bakerian Lecture, the author shows that the ordinary gaseous state is characterized by the ratio of the external pressures for all the homologues of any two given temperatures being constant, or

$$\frac{p}{p'}=\mathfrak{M}, \quad \text{(B)}$$

where $\mathfrak{m}$ is a constant. It must be carefully observed that v and v' in equation (A) are the volumes of the gas on different isothermals.

It follows from these results that, in the case of a body in the ordinary gaseous state, if the relations of pressure and volume are known at any one temperature, the corresponding relations at any other temperature can be calculated from the observation of a single homologue at the second temperature. Thus the whole relations of volume and pressure will be known from a set of primary observations at a fixed temperature and the determination of one homologue for each of the other temperatures.

The general form of the primary curve itself, or curve exhibiting the relations of pressure and volume at a given temperature, is next investigated; and the author finds, as the result of all his experiments under very varied conditions of temperature and pressure, that the value of $\epsilon(1-\rho)$ is constant for the same temperature. Hence we have for the third equation of the ordinary gaseous state

$$v(1-pv)=c \quad \text{(C)}$$

From this last equation the relations of homologous points, as defined by equations (A) and (B), may be deduced.

The author concludes with some general observations on the action of the internal attractive forces in the ordinary gaseous state, and also on the resistance to diminution of volume which, under certain conditions, modifies largely the effects both of external pressure and of internal attraction.

Presents received, April 6, 1876.

Transactions.

Angers:—Société Industrielle et Agricole. Bulletin. 46e année. 1er trimestre. 8vo. 1875. The Society.

Cherbourg:—Société Nationale Académique. Mémoires. 8vo. 1875. The Society.

Lund:—Universitet. Ars-skrift (Acta). Tome XI. 1874. Mathematik och Naturvetenskap. 4to. 1874–75. Biblioteks Accessions Katalog, 1872, '73, '74. 8vo. 1873–75. The University.

Montreal:—Natural-History Society. The Canadian Naturalist and Quarterly Journal of Science. New Series. Vol. VII. No. 7, 8; Vol. VIII. No. 1. 8vo. 1875. The Society.

Perpignan:—Société Agricole, Scientifique et Littéraire des Pyrénées Orientales [Mémoires]. Vol. XVIII., XXI. 8vo. 1871–74. The Society.

Rome:—Accademia Pontificia de' Nuovi Lincei. Atti. Anno 28. Sess. 7; Anno 29. Sess. 1, 2. 4to. *Roma* 1875–76. The Academy.